

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICATION FOR LETTERS PATENT

* * * * *

Methods Of Forming Memory Circuitry

* * * * *

INVENTORS:

Kunal R. Parekh
Byron N. Burgess

ATTORNEY'S DOCKET NO. MI22-2260

Methods Of Forming Memory Circuitry

TECHNICAL FIELD

[0001] The invention is related to methods of forming memory circuitry.

BACKGROUND OF THE INVENTION

[0002] Many types of memory circuitry utilize a combination of word lines, bit lines and capacitors which are arranged to form one or more memory arrays. In some instances, the bit lines are formed elevationally higher than or overlapping with the capacitors, while in other instances the bit lines are formed elevationally lower than the capacitors. Regardless, peripheral control or other circuitry is commonly fabricated at some location external to the array, and is conventionally referred to as peripheral circuitry. Such circuitry typically includes local interconnect lines which interconnect various conductive nodes of different devices in the peripheral circuitry. Such nodes might constitute metal or metal compounds and/or diffusion regions of common or differing conductivity types.

[0003] While the invention was motivated in addressing processing associated with the above-described circuitry, it is in no way so limited. The invention is only limited by the accompanying claims as literally worded, without interpretative or other limiting reference to the specification, and in accordance with the doctrine of equivalents.

SUMMARY OF THE INVENTION

[0004] The invention includes methods of forming memory circuitry. In one implementation, a semiconductor substrate includes a pair of word lines having a bit node received therebetween. A bit node contact opening is formed within insulative material over the bit node. Sacrificial plugging material is formed within the bit node contact opening between the pair of word lines. Sacrificial plugging material is removed from the bit node contact opening between the pair of word lines, and it is replaced with conductive material that is in electrical connection with the bit node. Thereafter, the conductive material is formed into a bit line.

[0005] Other aspects and implementations are contemplated.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Preferred embodiments of the invention are described below with reference to the following accompanying drawings.

[0007] Fig. 1 is a fragmented, diagrammatic sectional view of semiconductor wafer fragments in process in accordance with an aspect of the invention.

[0008] Fig. 2 is a view of the Fig. 1 wafer fragments at a processing step subsequent to that shown by Fig. 1.

[0009] Fig. 3 is a view of the Fig. 2 wafer fragments at a processing step subsequent to that shown by Fig. 2.

[0010] Fig. 4 is a view of the Fig. 3 wafer fragments at a processing step subsequent to that shown by Fig. 3.

[0011] Fig. 5 is a view of the Fig. 4 wafer fragments at a processing step subsequent to that shown by Fig. 4.

[0012] Fig. 6 is a view of the Fig. 5 wafer fragments at a processing step subsequent to that shown by Fig. 5.

[0013] Fig. 7 is a view of the Fig. 6 wafer fragments at a processing step subsequent to that shown by Fig. 6.

[0014] Fig. 8 is a diagrammatic top plan view of Fig. 7.

[0015] Fig. 9 is a view of the Fig. 7 wafer fragments at a processing step subsequent to that shown by Fig. 7.

[0016] Fig. 10 is a view of the Fig. 9 wafer fragments at a processing step subsequent to that shown by Fig. 9.

[0017] Fig. 11 is a view of the Fig. 10 wafer fragments at a processing step subsequent to that shown by Fig. 10

[0018] Fig. 12 is a view of the Fig. 11 wafer fragments at a processing step subsequent to that shown by Fig. 11.

[0019] Fig. 13 is a view of the Fig. 12 wafer fragments at a processing step subsequent to that shown by Fig. 12.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] This disclosure of the invention is submitted in furtherance of the constitutional purposes of the U.S. Patent Laws "to promote the progress of science and useful arts" (Article 1, Section 8).

[0021] Exemplary preferred embodiments of methods of forming memory circuitry are described with reference to Figs. 1-13. The particular circuitry described is with respect to DRAM circuitry and with respect to buried bit line memory circuitry. However, certain aspects of the invention are in no way so limited. Referring to Fig. 1, a semiconductor wafer fragment in process is shown generally with reference numeral 10, and includes a semiconductive substrate 22. In the context of this document, the term "semiconductor substrate" or "semiconductive substrate" is defined to mean any construction comprising semiconductive material, including, but not limited to, bulk semiconductive materials such as a semiconductive wafer (either alone or in assemblies comprising other materials thereon), and semiconductive material layers (either alone or in assemblies comprising other materials). The term "substrate" refers to any supporting structure, including, but not limited to, the semiconductive substrates described above. Further in the context of this document, the term "layer" encompasses both the singular and the plural unless otherwise indicated. Substrate 22 is shown in the form of bulk monocrystalline substrate, although semiconductor-on-insulator substrates and any other

semiconductor substrate, whether existing or yet-to-be developed, are of course contemplated. The preferred embodiment substrate 10 is depicted as having a memory array area 12 and a peripheral circuitry area 14 peripheral to memory array 12.

[0022] A plurality of spaced-apart word lines 19, 21, 23 and 25 is formed over substrate 22, and in part defines individual substrate locations 26, 28 and 30 with which electrical communication is desired. Substrate locations 26 and 30, on opposite sides of substrate location 28, constitute locations with which electrical communication will be established with individual storage capacitors, and are referred to herein as capacitor nodes. Substrate location 28 constitutes a location with which electrical communication will be established with a bit line, and is herein referred to as a bit node. In a preferred embodiment, the substrate locations comprise diffusion regions 27, 29 and 31, respectively, which are received within substrate 22. However of course, nodes 26, 28 and 30 might comprise other structures, for example elevated source/drains, plugs, etc., and include one or more conductive/semiconductive layers and whether existing or yet-to-be developed.

[0023] Word lines 19, 21, 23 and 25, and substrate locations 26, 28 and 30, are formed relative to an active area 32 which is isolated relative to other active areas by isolation regions 33, and which can be formed through conventional or yet-to-be developed techniques, such as shallow trench

isolation. Each exemplary preferred embodiment word line is depicted as including a gate oxide layer 37, a polysilicon layer 13 and a silicide or higher conductive layer 15. An insulative cap 17 is provided, as are insulative sidewall spacers 42. Other word line constructions and or materials can, of course, be utilized. For purposes of the continuing discussion, word lines 21 and 23 can be considered as comprising a first pair of word lines having a bit node 28/29 received therebetween, and word lines 23 and 25 can be considered as a second pair of word lines having a capacitor node 30/31 received therebetween.

[0024] Peripheral circuitry area 14, by way of example only, is depicted as having a first node 34 and a second node 35. Such might constitute common or differing conductivity diffusion regions, as depicted, or might constitute any other conductive material node location where it is desired in one implementation to form some sort of local interconnecting line interconnecting a first node and a second node in the peripheral circuitry area.

[0025] Referring to Fig. 2, insulative material 36 has been formed as part of substrate 10. An exemplary material is borophosphosilicate glass (BPSG), for example formed over an underlying layer (not specifically shown) of undoped silicon dioxide. Material 36 in the preferred embodiment has been planarized, for example by CMP, although planarization is of course not required. Further if planarized, such might be conducted to

produce an alternate construction, for example layer 36 could be planarized at least to the outer surface of caps 17. Regardless, a bit node contact opening 38 over bit node 28, capacitor node contact openings 39 and 40 over capacitor nodes 26 and 30, respectively, a first peripheral contact opening 41 over first node 34, and a second peripheral contact opening 42 over second node 35 have been formed within insulative material 36. Most preferably, the depicted contact openings are commonly formed, for example utilizing lithographic (i.e., photolithographic) patterning and etch steps which are common to the formation of the depicted contact openings. In the context of this document, “commonly forming” or “commonly formed”, and “commonly replaced” or “commonly replacing”, requires at least one or more processing steps which are common to the formation or removing of the stated material, structure or opening. Of course, the invention contemplates the fabrication of any and only a single one, or any subset, of the depicted contact openings as supported by the literal wording of the accompanying claims. However in the depicted embodiment, all openings are formed (preferably commonly) as shown in Fig. 2, and regardless whether material 36 has been planarized, and if so to what degree or point.

[0026] Referring to Fig. 3, sacrificial plugging material 44 is formed within bit node contact opening 38, capacitor node contact openings 39 and 40, first peripheral contact opening 41 and second peripheral contact opening 42. The sacrificial plugging material might comprise insulative material, conductive material (including conductively doped semiconductive

material) and/or semiconductive material regardless of whether conductively doped. By way of example only and in the depicted preferred embodiment, sacrificial plugging material 44 is shown as being in the form of a thin insulative liner 45 (i.e., silicon nitride or undoped silicon dioxide) having a doped or undoped planarized layer of polysilicon 46 formed thereover. Such are exemplary preferred materials where diffusion regions 27, 29, 31, 34 and 35 comprise silicon to provide an etch stopping barrier between preferred polysilicon material 46 and such diffusion regions, as will be apparent from the continuing discussion. Alternately by way of example only in the depicted embodiment, an interfacing etch stopping oxide might be formed essentially only at node locations 26, 28, 30, 34 and 35 by a thermal or plasma oxidation of the material of the respective diffusion regions. Regardless, in the exemplary preferred embodiment, sacrificial plugging material 44 is commonly formed with respect to openings 38, 39, 40, 41 and 42.

[0027] Referring to Fig. 4, sacrificial plugging material 44 and insulative material 36 have been planarized back (i.e., by chemical-mechanical polishing) proximate to, more preferably at least to, an outer surface of insulative caps 17. Thereafter, an insulating layer 48 has been deposited. An exemplary material is undoped silicon dioxide deposited by decomposition of tetraethylorthosilicate, with an exemplary thickness for layer 48 being 400 Angstroms. Contact openings/removal openings 50 have been etched therethrough to sacrificial plugging material 44 within bit node

contact opening 38, first peripheral contact opening 41 and second peripheral contact opening 42. Exemplary preferred techniques for doing so include lithographic patterning and etch.

[0028] Referring to Fig. 5, sacrificial plugging material 44 has been removed from bit contact opening 38, first peripheral contact opening 41 and second peripheral contact opening 42 while leaving sacrificial plugging 44 within capacitor node contact openings 39 and 40. Preferred removing techniques are by etching, with such etching removing the sacrificial plugging material from the bit node, first peripheral and second peripheral contact openings through removal openings 50. For example, where the sacrificial plugging material includes a polysilicon material 46, an exemplary etching chemistry is aqueous tetramethylammonium hydroxide. This can be followed by a short timed etch of insulative layer 45 (for example using an HF based chemistry for silicon dioxide, a fluorocarbon chemistry for silicon nitride) to clear layer 45 from over nodes 28, 34 and 35, as shown.

[0029] Referring to Fig. 6, the removed sacrificial plugging material has been replaced with conductive material 52 that is in electrical connection with bit node 28, first node 34 and second node 35. Preferably, such material is commonly replaced by deposition common to the substrate and the respective openings to result in the exemplary Fig. 6 construction. In the illustrated example, conductive material 52 comprises a first layer 54 and a second layer 56. By way of example only, layer 54 might be formed to

to provide a diffusion barrier function between substrate 22 and conductive layer 56, and/or to provide an adhesion/glue layer function to facilitate adherence of layer 56 to the ultimate substrate. By way of example only, exemplary materials for layer 54 include conductive metal silicides (whether chemical vapor deposited or formed by a silicide or other process), and conductive metal nitrides (whether stoichiometric, enriched in metal or other material), as well as any other conductive material. An exemplary material for layer 56 is an elemental metal or an elemental alloy, for example tungsten. Of course, conductive material 52 could comprise a single, or more than the illustrated two, layers and be any conductive material, including conductively doped semiconductive material. An insulative capping layer 58 (i.e., silicon nitride) is formed over conductive material 52.

[0030] Referring to Figs. 7 and 8, conductive material 52 has been formed into a bit line 60 and a local interconnect line 62. The top plan layout depicted by Fig. 8 is merely an exemplary layout. Alternate layouts, whether existing or yet-to-be developed, could also of course be employed, for example as shown in our U.S. Patent No. 6,458,649. An exemplary preferred method for forming the conductive material into the illustrated bit line and local interconnect line includes lithography (i.e., photolithography) and etch. However, any method of forming the respective materials into one or both of the illustrated lines is contemplated, whether existing or yet-to-be developed. For example, and by way of example only, such bit line forming could be by a damascene process. For example, some suitable insulative

material could be deposited over the Fig. 5 construction, with desired line-shaped troughs and contact openings etched therein. Conductive material could then be formed to overfill such troughs and openings and the conductive material planarized back to define the desired isolated conductive line outlines. In one preferred embodiment, the illustrated patterning to form lines 60 and 62 comprises lithography and etch using at least some common lithographic and etching steps to the depicted layers, for example such that a single masking is conducted.

[0031] Referring to Fig. 9, anisotropically etched insulative sidewall spacers 64 have been formed about the respective lines 60 and 62. An exemplary preferred material is silicon nitride.

[0032] Subsequent processing will preferably form a capacitor of a memory cell of the memory circuitry after having formed the bit line and local interconnect line. Such is shown, by way of example only, with respect to Figs. 10-13. Referring to Fig. 10, another insulative layer 66 has been deposited. An exemplary material is BPSG. Openings 68 have been formed therethrough, and through insulative material 48 over sacrificial plugging material 44 received within remnant portions of capacitor node contact openings 39 and 40.

[0033] Referring to Fig. 11, sacrificial plugging material 44 has been removed from capacitor node contact openings 39 and 40, for example as

described above with respect to sacrificial material removal from openings 38, 41 and 42.

[0034] Referring to Fig. 12, conductive material 70 has been deposited and planarized back to fill openings 68. Such might, of course, include more than one conductive material.

[0035] Referring to Fig. 13, another insulative layer 72 has been deposited. Storage node container openings 74 have been formed therein, and a storage node 76, a capacitor dielectric layer 78 and a common outer capacitor plate 80 formed, as shown. Further and by way of example only, a contact opening (not shown) could be formed to local interconnect line 62 commensurate with the forming of container openings 74.

[0036] Such provides but one example of forming exemplary capacitors of respective memory cells of memory circuitry in electrical connection with capacitor nodes 26 and 30, and whereby an elevationally outermost electrode (i.e., 80) of a capacitor is received everywhere elevationally outward of the illustrated bit line. Of course, attributes of the invention might be practiced in the formation of memory circuitry not comprising buried bit line memory cells without departing from certain principles and aspects of the invention.

[0037] By way of example only, and not in any way of limitation, the invention might provide an advantage over certain previous technology in the provision of low resistant contacts to the digit line node while enabling the commensurate fabrication of one, more or all local interconnect lines within the periphery between various metal, metal compound, n+ and p+ regions, with reduced masking steps where masking is utilized.

[0038] In compliance with the statute, the invention has been described in language more or less specific as to structural and methodical features. It is to be understood, however, that the invention is not limited to the specific features shown and described, since the means wherein disclosed comprise preferred forms of putting the invention into effect. The invention is, therefore, claimed in any of its forms or modifications within the proper scope of the appended claims appropriately interpreted in accordance with the doctrine of equivalents.